Navigating Undergraduate Research:
A Timeline of Opportunities

IUJUR Research Day

Saturday, Dec. 1st, 2018

IUJUR
THE INDIANA UNIVERSITY JOURNAL OF UNDERGRADUATE RESEARCH

Introductions

- Who are we?
  - IUJUR's Natural Science Board

IUJUR
THE INDIANA UNIVERSITY JOURNAL OF UNDERGRADUATE RESEARCH


Bryce Cousins


Kelli Michaels


Rachel Kalbfell


Sakhi Shah


Brock Glaser


Nick Thelen


Hana Shafique


Jimmy Atterholt

Introductions

- Who are you?
  - Years?
  - Post-grad plans?
  - Research experience?

Research at IU

- **R1** Research University
- IU ranks as **54th** most innovative university in the world
- **32nd** among U.S. universities
- **$604.4 million** in external funding for research and other activities in 2018

200+

IU research centers and institutes in all areas of study

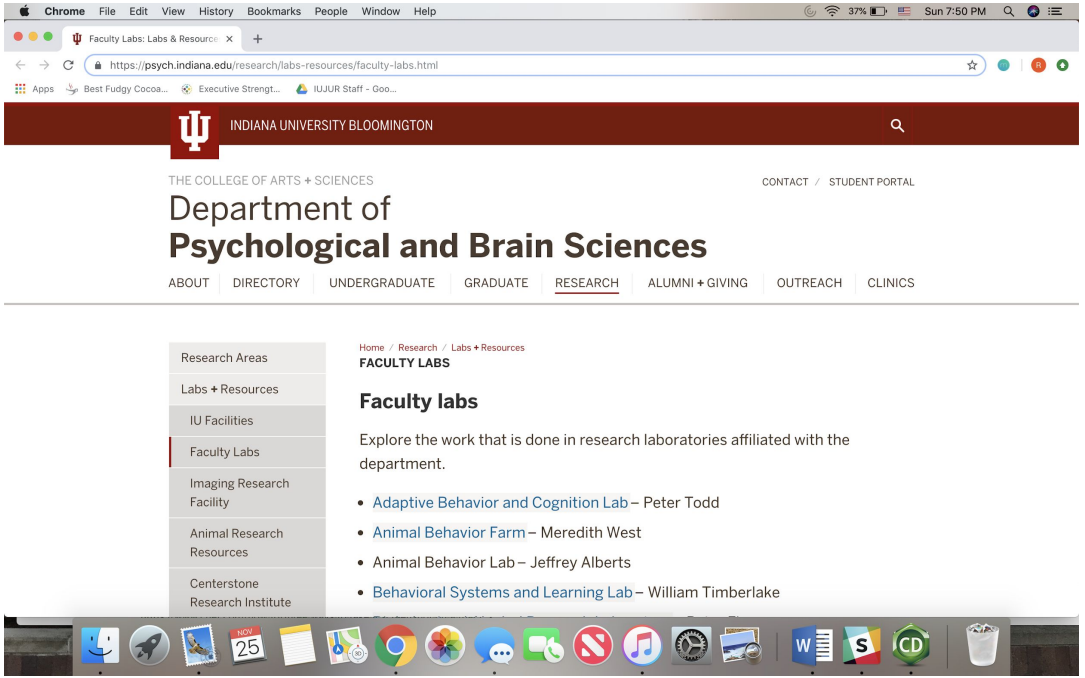
- Starting Research -

Freshman-Sophomore year

Finding and Starting Research

Example: https://psych.indiana.edu/research/labs-resources/faculty-labs.html

- Where to start when looking for a lab:
  - → Departmental Websites
    - → Laboratory Directories



How to Contact

Who to contact:

- Departmental Heads (ex. Director of Undergraduate Studies)
- Current Faculty
- Current Graduate Faculty
- Research for credit

Most common ways of contacting:

- Email
- IU-specific research program matching
- Talking to professors in class

How to Contact

1. Introduce yourself
2. Outline any relevant past experiences you might have (classes, previous research, etc.)
3. Briefly describe why you are interested in this particular research field
4. Thank them & close

Subject of this email: Sophomore Undergraduate Research Inquiry

Dear Dr. Kawata,

My name is Rachel Kalbfell, and I am a sophomore Wells Scholar at Indiana University Bloomington double majoring in biochemistry and Spanish. I am writing to inquire about any possible openings you may have for an undergraduate researcher.

insert past research experience here

Furthermore, as an avid athlete, I wanted to shift my research focus upon returning to Bloomington to something I had a greater tangible connection with. For this reason, I looked into the research in human performance occurring in the School of Public Health, where I found the description of your research interests. I played soccer for fifteen years of my youth, and concussions were a part of my teammate's and my reality on an almost weekly basis. I now compete as a cyclist for an independent team in the Little 500, a community in which accidents and head trauma also go hand in hand. Because of this, I find your research extremely relevant and important. I am also fascinated with neuroscience and would find delving into this knowledge field for research extremely rewarding.

As an undergraduate researcher, I have gained some bench research skills, but I hope to expand on this skillset significantly in the coming semester. I was trained to independently operate the TEM on the Bloomington campus last year. I am proficient in cell culture maintenance, Western blot tests, nucleofection, and flow cytometry along with a variety of basic laboratory skills. While I know these are not necessarily tools employed in your research, I am very flexible and capable of learning new skills quickly once taught.

Please let me know if you have any availability in your lab for an undergraduate student at this time. If you do, I would greatly appreciate the opportunity to meet with you to discuss this further. I can also provide any other information you may be curious about that I did not go into detail with here.

Research Programs: ASURE

Arts + Sciences Undergraduate Research Experience

- Biology and Humanities
- Introduction to research practices and methodologies
  - Coursework and CASE requirements
- Faculty-led research and project-based experiences

How to apply:

- Incoming IU freshman who achieve Direct Admission to CASE
- Select the ASURE box on the Selective Scholarship Application
- More questions?
  - Reach out to asuregen@indiana.edu

Research Programs: Cox Legacy

Build academic experience by engaging in a meaningful work experience with a department, office, or faculty member

- Full-ride program
- Work eight-ten hours each week of the fall and spring semesters

Additional participation in:

- Career preparation and development
- Community service projects
- Career and personal assessments

How to apply:

- Available for both incoming IU freshman and current students
- Current students: priority deadline is **February 5, 2019**
- Search and select “Scholarships” under One.IU, select “Other Recommended Opportunities,” and apply on “*IUB-Cox Legacy Scholarship Application*”

Research Programs: STARS

Science, Technology, and Research Scholars

- Research under guidance of a faculty mentor
- 10 hours per week in lab
- Ethics training
- Semester reports
- Opportunity to present and speak at specialized STARS symposiums
- Summer and travel funding

How to apply:

- Applications open for IU freshmen and sophomores
- Requirements:
  - 1-2 semesters of coursework
  - Major in a science within the College of Arts and Sciences

Application found on the Office of Science Outreach

- Email to jotracy@iu.edu

- Continuing Research -

Sophomore-Junior year

Summer Research at IU

Full-time summer research

- Gain experience and skills
- Prep for post-grad plans
- Make substantial headway on projects; inspire your own ideas

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Full-time summer research

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Funding

- Hutton Honors College (HHC)
  - $3000 for a summer
  - Apply before spring break
- STARS summer grants
  - $2000-$4000 for a summer
  - Apply through STARS
- Directly from your advisor

Summer Research Beyond IU

REUs in all STEM fields

- Through the National Science Foundation

Research Experiences For Undergraduates

- Room/Board + ~$5000
- **Very** competitive!
- Apply in January/February

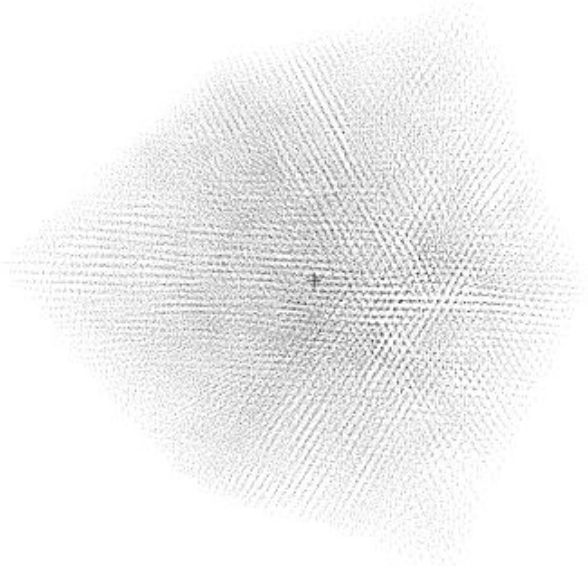
SURF programs

- Funded by Universities
- ~$4000-5000 + Room/Board
- Academic & Translational Research
- Focused on future MD, MD/PhD, and PhD students
- **Very** competitive- apps open November 1st
- **Rolling Admission**
- University-specific programs

Summer Research Beyond IU

Bryce: astronomy REU at Cornell

- Full-time research in cosmology: simulating the Universe to test string theory
- Presentations from students and professors
- Workshops & networking



Summer Research Beyond IU

Tips:

- Apply early (start looking now!)
  - Apply to many places (<10% accepted)
- Quality essays
- Strong letters of recommendation (2+)
- Prior research experience

Website:

https://www.nsf.gov/crssprgm/reu/index.jsp

Summer Research Beyond IU

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Benefits:

- Well-funded research
- Networking & professional development
- Research skills & resume points
- Funding to present at a national conference

Presenting

Why you should present

- Better understand your project
- Undergraduate conferences have lower stakes
- Practice speaking and answering questions
- Will help with some award applications

Presenting

List of Opportunities to Present:

- Hutton Honors College Spring Research Symposium (Spring)
- Center of Excellence for Women in Tech Poster Competition (anyone can attend) (Spring)
- IU Undergraduate Research Conference (Fall)
- STARS (anyone can attend) (Fall and Spring)

Presenting

Resources for Making Posters

- Canvas course “Creating Research Posters”
- Honors College workshop
- Look at sample posters around the building

Presenting

General Notes:

- Lab-specific template?
- Abstract
- Weird Questions
- Formality

Presenting

Mechanisms of suppression of Kv 1.1 by amyloid peptide fragment (1-42), (25-35)

INDIANA UNIVERSITY BLOOMINGTON

N. THELEN, K. DEBOEUF, J. FARLEY

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STARS Symposium 4/7/18

Introduction

Alzheimer's Disease (AD) is the most prevalent form of senile dementia. It is characterized by the presence of amyloid plaques and neurofibrillary tangles in the basal forebrain and hippocampus.[1] The plaques are primarily composed of 42 amino acids referred to as amyloid beta (Aβ) that are derived from the amyloid precursor protein.[2] Aβ is clearly neurotoxic, however, the mechanisms are unclear, setting the focus of the Farley Lab.[3]

Kv 1.1 is an α-subunit protein of a voltage dependent K$^+$ channel that exhibits delayed-rectifier type properties in neurons throughout the brain. Kv 1.1 participates in learning and memory in the hippocampal and cortical regions.[4] The Farley Lab studies the mechanism(s) of suppression by Aβ on Kv 1.1, which might be expected to contribute to the initiation of Ca^{2+} homeostasis disruption and synaptotoxicity. Kv 1.1 suppression has not been directly linked to AD; however, previous work shows that K$^+$ channel disruption may play a role in neurotoxic events that lead to AD and epilepsy.[5,6]

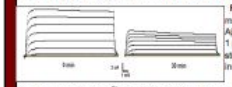

Figure 1: Representative set of macroscopic Kv 1.1 currents before Aβ addition and 30 minutes following 1 μM Aβ (1-42) addidition. Voltage steps ranged from –70 mV to 20 mV in +10 steps.

Previous experiments in the Farley Lab elucidated a Ca^{2+} dependent pathway that modulates macroscopic Kv 1.1 currents expressed in *Xenopus laevis* oocytes. It was found that Aβ's suppression of Kv1.1 was partially dependent (~50%) on intracellular Ca^{2+} levels and PP2B. The incubation in BAPTA-AM and Cyclosporine A yielded about ~25% suppression Kv 1.1 activity, half of the expected ~50% suppression caused by Aβ.[7] The remaining ~50% suppression has become a focus in the Farley Lab. More specifically, we have sought to determine whether Aβ can interact with Kv1.1 in a peptide-peptide manner, either intra- or extra-cellularly. These experiments were performed on both the macro– and microscopic level. The core peptide [Aβ(25-35)] was also evaluated on both macro– and microscopic levels to evaluate whether it was sufficient to cause suppression of Kv 1.1.

In the Black Lipid Membrane (BLM) experiments, Gramicidin A was utilized as an evaluation of bilayer quality. Gram A is a well-characterized peptide that can act as a transbilayer channel specific for monovalent cations.[8] The channel incorporates via dimerization requiring application on cis and trans side of bilayer.[9]

Methods

Murine Kv 1.1 was expressed in stage V and VI *Xenopus laevis* oocytes commercially provided by Ecocytes Bioscience (Austin, TX). A high expression cDNA plasmid of mKv 1.1 gene was transcribed into cRNA and then microinjected into the oocytes. The oocytes were incubated in ND96-PK for 1-2 days before experimentation.

Standard two microelectrode voltage clamp (TEVC) methods were used to evoke and record Kv 1.1 currents on a macroscopic level.[7] Using our standard protocol, a series of depolarizing steps (+10 mV/step) are administered in order to evoke Kv 1.1 currents. Recordings took place in standard ND96 bath solution.

Standard cell-attached patch clamp methods were used to evoke and record Kv 1.1 single channel currents. The vitelline membrane was removed following incubation in a slightly hypertonic solution to allow access to the cell membrane. Recorded cells maintained a seal of at least 1 GΩ during experimentation.

Standard "tip-dip" methods were used to form artificial bilayers with a lipid composition of 15 mM PE: 4 mM PS. Upon formation of bilayer, membrane vesicles (isolated from Kv 1.1-injected oocytes via sucrose gradient centrifugation[9]) were added to the bath for "inside-out" conformation. Black lipid membrane (BLM) bilayers were formed by painting a 20 mM PE: 6 mM PS mixture onto 110 micron septum in 1 M KCl, 10 mM HEPES "intracellular" cis side and 100 mM KCl, 10 mM HEPES "extracellular" trans side. The presence of an appropriately "thinned" bilayer was verified by a capacitance of at least 30 pF and resistance of ~10 GΩ. Membrane vesicles were added to cis side followed by gentle stirring. Gramicidin A was added 1 mg/mL to cis and trans side.

Results: TEVC

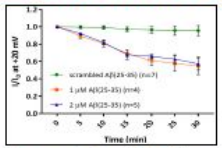

Figure 2. Preliminary experimentation exhibited a ~45% suppression of Kv 1.1 following 30 min exposure to Aβ (25-35). At a concentration of 1 and 2 μM Aβ (25-35), significant suppression of Kv 1.1 activity occurred on the macroscopic level. The scrambled peptide Aβ (25-35) did not appear to produce significant suppression.

Results: Ripped-off Patch

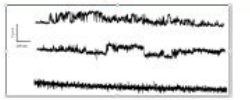

Figure 3: Single channel activity of Kv 1.1 and "intracellular" addition of Aβ (1-42). ***Top trace:*** Ripped-off channel activity before the addition of Aβ. ***Middle trace:*** 10 seconds following addition of Aβ. ***Bottom trace:*** 2 minutes following Aβ addition. The channel activity was completely suppressed and there was no recovery for the duration of the recording (n=2). In an additional single control experiment, extracellular Aβ failed to inhibit Kv 1.1 activity.

Results: Tip-Dip

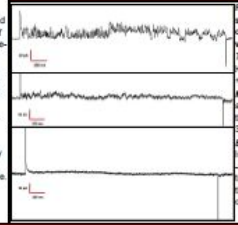

Figure 4: Aβ (25-35) exposure to "intracellular" side of "tip-dip" bilayer infused with Kv 1.1 membranes.
Top trace: Channel activity of Kv 1.1 incorporated vesicle at +40 mV before Aβ addition.
Middle trace: Channel activity at +40 mV, 10 seconds after the addition of 1 μM Aβ (25-35).
Bottom trace: 2 minutes following addition of 1 μM Aβ (25-35). Channel activity appears to be completely eliminated by the intracellular addition of the core peptide, Aβ (25-35). (n=2)

Results: BLM

Figure 5: Gramicidin A incorporation into planar lipid bilayer. ***Top trace:*** The bilayer was held at 0 mV in a 500 mM KCl, 1 mM $CaCl_2$ solution on the cis side and 100 mM KCl, 1 mM $CaCl_2$ on the trans side.
Bottom trace: 5 μL of gA (1 mg/mL in ethanol) was added to both the cis and the trans side and held at 0 mV. Trace shown was taken 1 minute following addition, however, the effect was instantaneous. Capacitance ~30 pF, ~8 GΩ, 80 micron septum, 5 mM DPhPC (n=3).

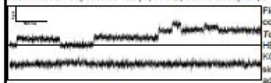

Figure 6: Kv 1.1 channel incorporation to planar bilayer. ***Top trace:*** 1 M KCl, 10 mM HEPES on cis side, 100 mM KCl, 10 mM HEPES on trans side. Vesicle preparation was added to the cis side and stirred until incorporation, held at 0 mV. ***Bottom trace:*** Addition of 10 mM TEA to cis side, held at 0 mV. Traces demonstrate incorporation and activity of multiple Kv 1.1 channels. Kv 1.1 activity was immediately eliminated with the addition of TEA, a specific K$^+$ channel blocker (n=1).

Summary and Conclusion

The TEVC data demonstrated that the core peptide, Aβ (25-35), is capable of producing suppression on the macroscopic level at both 1 and 2 μM. This finding verifies that the core peptide, Aβ (25-35), plays a major role in the suppression of Kv 1.1, and may largely be responsible for the Kv1.1 suppression we saw with the longer Aβ(1-42) peptide.

Shifting focus to the microscopic level, oocyte ripped-off patch clamp data suggested that Aβ (1-42) can interact directly with the intracellular face of Kv 1.1 and cause suppression of channel activity. More experiments are required to verify this effect.

Supporting the findings of the ripped-off patch clamp data in oocytes, tip-dip data also focused on intracellular Aβ using artificial bilayers. The tip-dip data demonstrated that the intracellular addition of Aβ (25-35) could elicit a suppressive effect. The channel activity at the single channel level appeared to be completely eliminated with the intracellular Aβ addition. More experimentation is necessary to verify this effect and increase the *n* value.

To further evidence the intracellular activity of Aβ and gather extracellular Aβ data, the BLM protocol was employed. The BLM data demonstrated that the bilayer painting method was effective in producing stable planar bilayers with the ability to incorporate ion channels. Further, we were able to induce the incorporation of Kv 1.1 into the lipid bilayer and verify its presence through the addition of TEA. Through increased experimentation and perfection of protocol, the Farley Lab will further study the effect of Aβ (1-42) and (25-35) on the intracellular and extracellular faces of the Kv 1.1 channel.

Our data demonstrate that Aβ (1-42) and (25-35) produce a rapid suppression of Kv 1.1 on the macroscopic and microscopic level. Further, on the microscopic level, it appears that suppression of Kv 1.1 by Aβ occurs intracellularly which could explain the Ca^{2+}-independent mechanism of suppression accounting for ~50% of the total suppression by Aβ (1-42).

References

1. Cassell RJ, Beach TG, Yearl R, and Reiman EM (2006). J Clin Psychiatry 67: 1784-1800.
2. Walsh DM, Minogue AM, Fitgerlo S C, Fadeeva JV, Wasco W, and Selkoe DJ (2007). Biochem Soc Trans 35: 416-420.
3. Hardy J, and Selkoe DJ (2002). Science 297: 353-356.
4. Grosse G, Draguhn A, Hohne L, Tapp R, Veh RW, and Ahnert-Hilger, G (2000). J Neurosci 20: 1869-1882.
5. Bomben V, Hoth J, Reed J, Cramer P, Landreth G, & Noebels J (2014). Neurobio of Aging, 35(9): 2091–2095.
6. Scala et al. (2015). Neurobiology of Aging, 36(2), 886–900.
7. Hallahan BJ, Islam, MY, and Farley J (2017). Manuscript submitted for publication.
8. Kelkar DA, Cattopadhyay A (2007). Biochimica et Biophysica Acta (BBA) - Biomembranes. 1768(9): 2011–2025.
9. Morera et al. (2007). Methods Mol Bio 400: 571-85.

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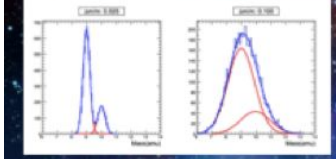
Presenting

Precise Characterization of High Energy Light Isotopes

Kelli Michaels, J. Musser, M. Gebhard, M. Lang

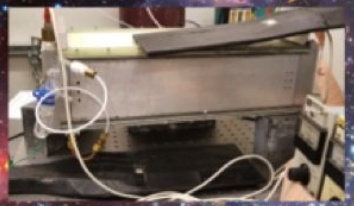
Background: Our understanding of cosmic ray astrophysics has developed significantly in recent years, largely thanks to new balloon-based and space-based data collection methods as well as advancements in computational modeling of cosmic ray behavior. Satisfactory measurements have been made of the relative abundances of light cosmic ray isotopes at fairly low energies, revealing new information about the propagation and origins of cosmic rays. However, cosmic rays cannot be fully understood without measuring these abundances for cosmic rays at much higher relativistic energies. This is the goal of HELIX, the High Energy Light Isotope eXperiment.

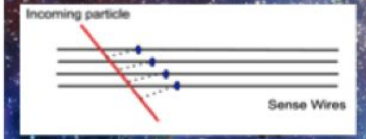


Schematic depiction of the effect of mass resolution on isotope separation. The left figure shows the 10Be/ 9Be mass peaks obtained for an instrument with 2.5% mass resolution. The right figure shows the same, but for 10% mass resolution. An intrinsic ratio of 10Be/ 9Be = 0.3 is assumed (Wakely et al)

Research goals: . The main challenge that HELIX faces in meeting its goals is achieving a very high mass resolution; in order to differentiate between different high-energy isotopes accurately, a mass resolution of at least 0.25 amu must be achieved. HELIX plans to obtain such precise data by using a combination of a long exposure time (up to 14 days) and cutting edge spectrometer and detector technologies.

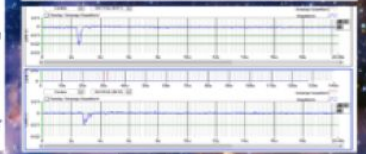
Research Methods: Here at IU, a prototype of the drift chamber is currently being tested and optimized. Construction of the final chamber began in 2018.





Basic diagram of the particle detector. As particles pass through, they leave a trail of ions which drift to the sense wires.

The below photo shows a sample read out from the drift chamber. The analog signals from the drift chamber are read and converted to a digital output at a rate of 80MHz when triggered by electronics in the muon paddles. This process is automated via an extension in Matlab.



Wire Tension: The sense wires having correct tension on them is key to their function. Ensuring this is difficult because they are very thin and delicate. We use a special technique to indirectly measure tension.

The above photos show how the current in the circuit on the left changes when a strong magnet is held to the wire under test. The frequency of the waves on the right can be used to calculate the tension on the wire without direct force on the delicate wire.

The below phot shows the progress of construction of the final drift chamber. The final chamber will have 216 sense wires compared to 8 in the proto-chamber. The chamber has a volume of about 1 m^3.

Conclusions: Though some adjustments to technique will be needed, construction is proceeding well and we are optimistic about the results of the experiment.

Publishing

Why publish?

- Communicate new research and discoveries
- Advance your field and impact future research
- Publishing contributes to your reputation in research careers

Publishing as an Undergraduate:

- Involves faculty mentor or graduate student oversight
- Shows significant contribution to a project
- Solidifies your knowledge on your research subject

Publishing

IUJUR

- Opportunity to independently write publication
  - 1st Author
- Peer-reviewed IU journal
- More format options
  - Publish incomplete work/without data through a research snapshot
- Gain publishing experience

Deadlines:

- Priority Deadline
  - February 23rd, 2019
  - Allows for early acceptance or revisions before resubmission by final deadline
- Final Deadline
  - April 13th, 2019
- Step-by-step guide:
  - iujur.iu.edu

Senior Thesis

Why?

- Form an close relationship with professors in your field of interest
- Develop experience with research methodology
- Be a competitive applicant for graduate or medical school
- Produce an original manuscript as a basis for further research

Senior Thesis

What is it?

- Departmental Honors:
  - Sophomore/junior year
  - 3.3 GPA
  - Faculty sponsor
  - Concludes with a manuscript and presentation
- Biology: 6 credits hours BIOL-X490
- Psychological and Brain Sciences: 6 credit hours P499
- Physics: 3.5 GPA; two of three honors courses
- Mathematics: 3.5 GPA; sequence of honors classes; advanced senior-level course sequences

Senior Thesis

Finding a topic

- Read literature in a subfield that interests you, and explore research in your lab
- Read papers published by your lab and explore available equipment and techniques
- Set a recurring meeting with your faculty mentor
- Choose a topic that is relevant and interesting to your faculty mentor & grant committees

Senior Thesis Timeline

Start research	Freshman-junior year
Project outline, meeting with faculty	2nd semester junior year-1st semester senior year
Write grant proposal and literary basis for study, secure funding	Junior-senior year
Draft, draft again	Senior year
Present and defend thesis	Before graduation

- Graduation Prep -

Senior year

Graduate School in STEM

Reasons to apply:

- Prepares you for a research career
- Build additional skills for industry careers
- Opens up doors for more specialized employment opportunities

Options:

- Masters (MS)
  - Useful for industry jobs
  - 1-3 years
- Doctorate (PhD)
  - Prep for a research career (academia, industry, etc.)
  - Doesn’t require MS
  - 4-6 years

Graduate School in STEM

Funding:

- PhD: usually funded!
  - Through TAs, RAs, or fellowships
- MS: nuanced
  - Depends on field and program

MD/PhD Programs

- Physician-Scientist trained in both clinical patient care and research
- Application:
  - Through AMCAS
  - Additional Essays
  - Standardized tests- MCAT & potentially the GRE
  - App opens June 1- early you apply the better. Can be deferred to the MD pool of applicants if rejected to the MD/PhD program.
- Timeline 2 years of medical school (coursework), then 4 years of graduate school, then finish the last 2 years of med school (rotations)
- Medical School tuition waived, receive a stipend. Better placement in residencies or postdocs. Can choose to focus on research, clinical work, or both. Research-focused on disease mechanisms.
- https://students-residents.aamc.org/choosing-medical-career/article/why-pursue-md-phd/

Preparing for Grad School

Finding graduate schools

- Grad school fairs
- Online databases:

https://www.petersons.com/graduate-schools.aspx

http://www.phds.org

https://www.princetonreview.com/grad-school-search

https://ocs.fas.harvard.edu/graduate-school/ma-phd-programs

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Refining your choices

- Talking with advisor and grad students
- Exploring lab websites and publications
- Contacting specific faculty

THE COLLEGE OF ARTS + SCIENCES
WALTER CENTER
FOR CAREER ACHIEVEMENT

INDIANA UNIVERSITY BLOOMINGTON

GradSchoolShopper

Applying to Grad School

Timeline

- Never too early to start!
- Grad school fairs every fall
- **Deadlines between November and February**
  - Varies with field and school - make a list!
- Interviews/visits in Spring
  - Decisions between March and May

Application requirements

- Personal statement
- Letters of recommendation
- Transcript
- Resume/CV
- GRE scores

Applying to Grad School

Standardized Exams

- General GRE
  - For most programs
- Subject GRE
  - Physics, Psych, etc.
  - For some programs

Timeline

- GRE: fall of senior year
- Subject GRE: spring of junior year; fall of senior year
- Scores are valid for 5 years

ETS® GRE®

Applying to Grad School

Fellowships & National Awards

- Separate from grad school applications
- For extra funding and prestige
- **Many** are available, but are **very** competitive!
- Deadlines vary; usually October-January

the Hertz FOUNDATION
freedom to innovate

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Many resources available online:

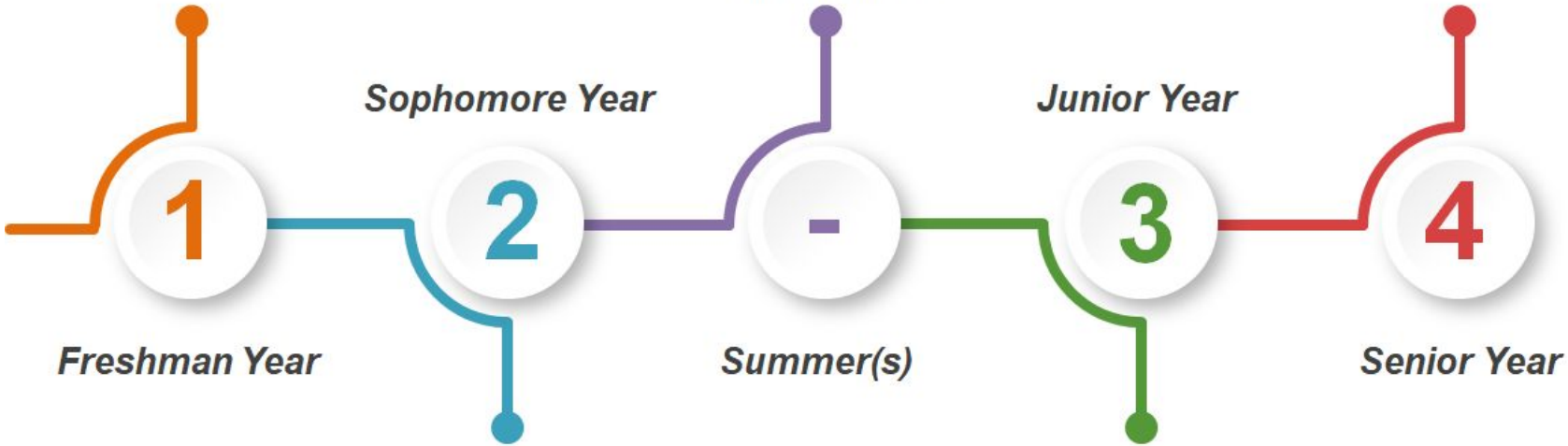
https://grad.ncsu.edu/students/fellowships-and-grants/national/nationally-competitive-graduate-fellowships/

https://nsa.indiana.edu/getting-started/iu-administered-awards.html

https://pathwaystoscience.org/index.aspx

https://nsa.indiana.edu/ - Paul Fogleman: here at a booth today!

Final Timeline



Getting Started
- Contact professors; seek research positions
- Applying to research programs (Cox Legacy; STARS)
- Take research classes for credit

Starting/Continuing Research
- Late Fall/Spring.: prepare for summer programs (REUs, SURF)
- Spring: attending research conferences

Seek & Attend Research Programs
- REUs; SURF; other programs
- Gather and present results
- Develop ideas for your own independent projects

Explore Research
- Fall/Spring: present posters at conferences
- Prepare for summer programs
- Spring: consider grad school & the GRE
- Spring: explore options for a senior thesis

Prep for Graduation
- Fall: explore and apply for grad schools
- Fall/Spring: apply for fellowships & awards
- Fall/Spring: continue senior thesis
- Spring: visit grad schools, and graduate!

Thank you!

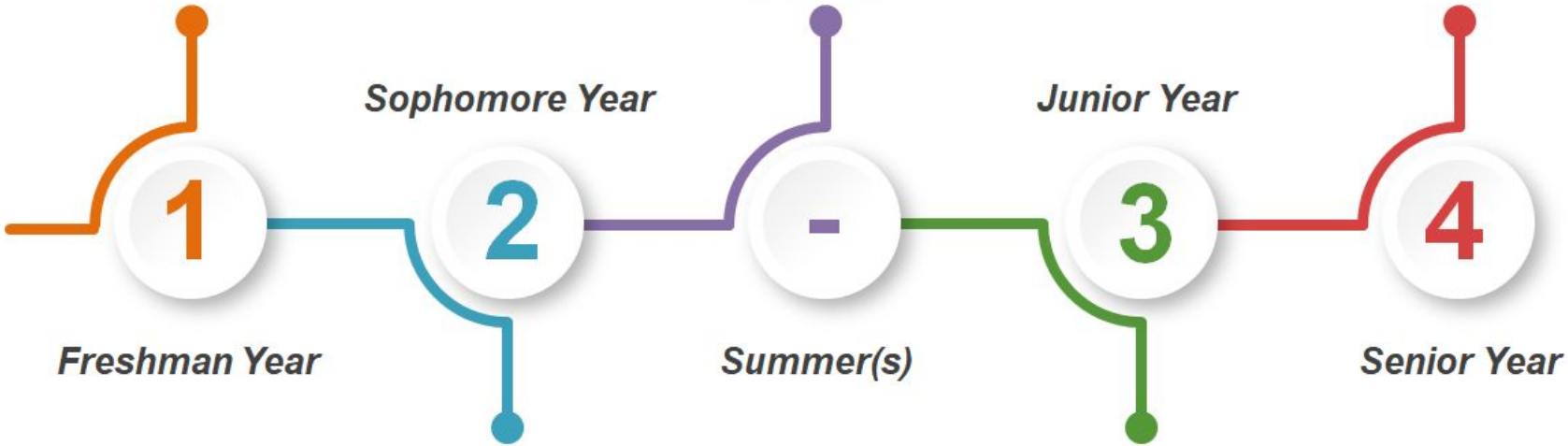
IUJUR Research Day

Saturday, Dec. 1st, 2018

IUJUR

THE INDIANA UNIVERSITY JOURNAL OF UNDERGRADUATE RESEARCH

Final Timeline



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References

Images:
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